EARTH TECH | AECOM

Assess for Less:
A Solution-Oriented, Ground-Based Geomorphic Analysis of an Urban Watershed in the Piedmont of North Carolina.

October 14, 2008

Background

- Watershed approaches in NC, including those Earth Tech has conducted, have focused on:
- Making recommendations to local governments for management of watersheds.
  - These recommendations largely informed by GIS-based analysis.
- Providing locations of potential mitigation sites.
- Giving a qualitative rating to subwatersheds to guide future analysis and implementation strategies.

Background

Big issues:

- What is the overall approach to improving water quality within an urban watershed?
- How do we get from the observation of a problem, to the implementation of solution that can treat the sources of this problem?
- How do we know this solution is one that deserves priority over others?
- If we want to see solutions implemented across the southeast, how can we find the most efficient, cost-effective method to generate this solution?

The Bolin Creek Watershed Geomorphic Analysis and Potential Site Identification for Stormwater Structures and Retrofits

- This project focused on a process that could take an analysis to the logical conclusion of generating solutions to treat the identified problems.
- In many ways, the BC project was a "guinea pig" project that sought to answer the question:
- Can a small grant provide the resources necessary for a municipality to assess the geomorphic state of a watershed, locate potential locations for stormwater structures and retrofits, and develop conceptual-level plans and cost-estimates with sufficient detail to provide the basis for further grant funding?

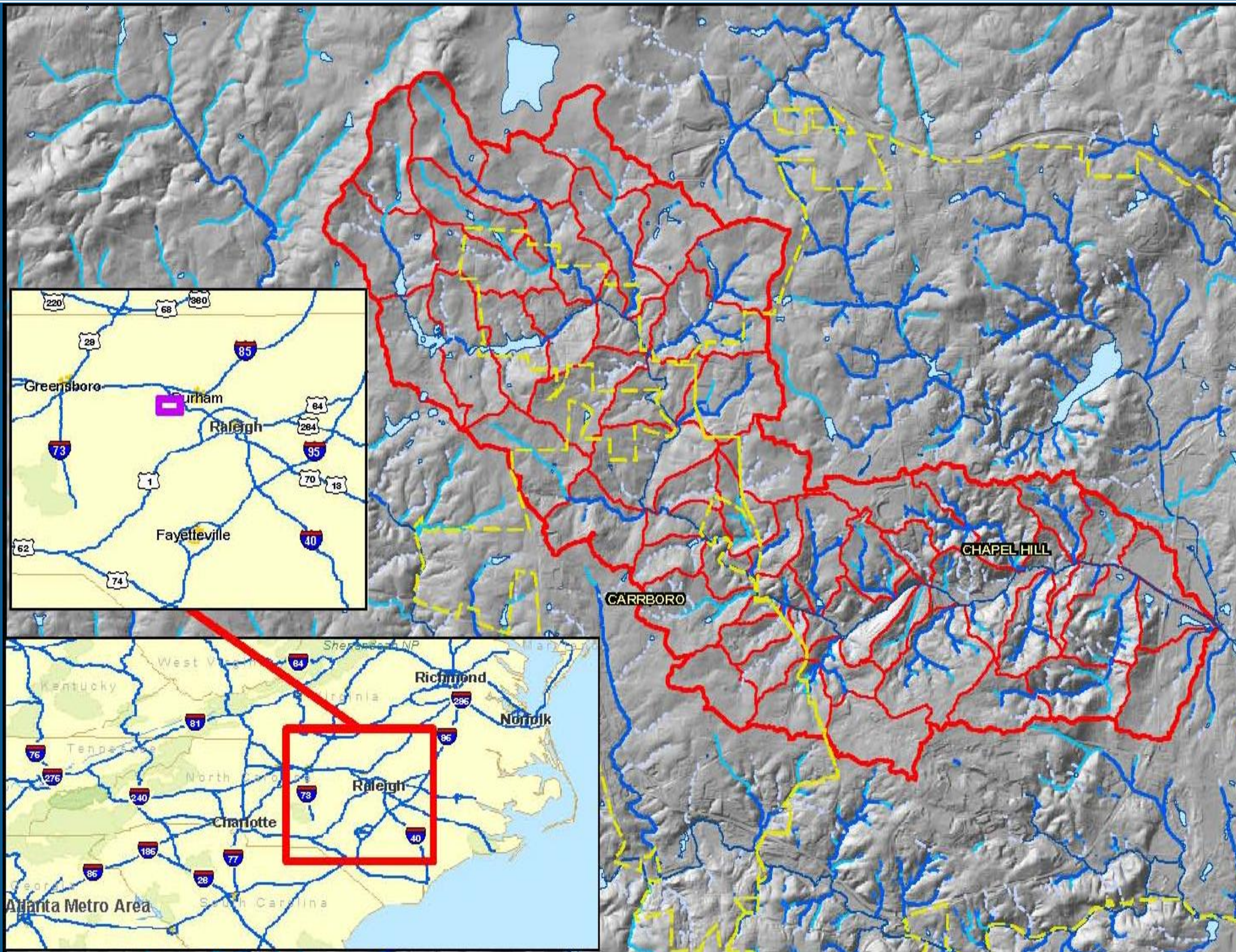
The big vision: municipalities given these "mini-grants" will use it to identify projects most deserving of funding within their watersheds, and apply for grants to fund these projects.

The Bolin Creek Watershed

- **Drainage Area** = 12.4 sq. mi.
- Part of Cape Fear River Basin
- **Location:** Towns of Chapel Hill and Carrboro, North Carolina
- **Physiographic Location:** Slate Belt of Piedmont, partially in Triassic Basin

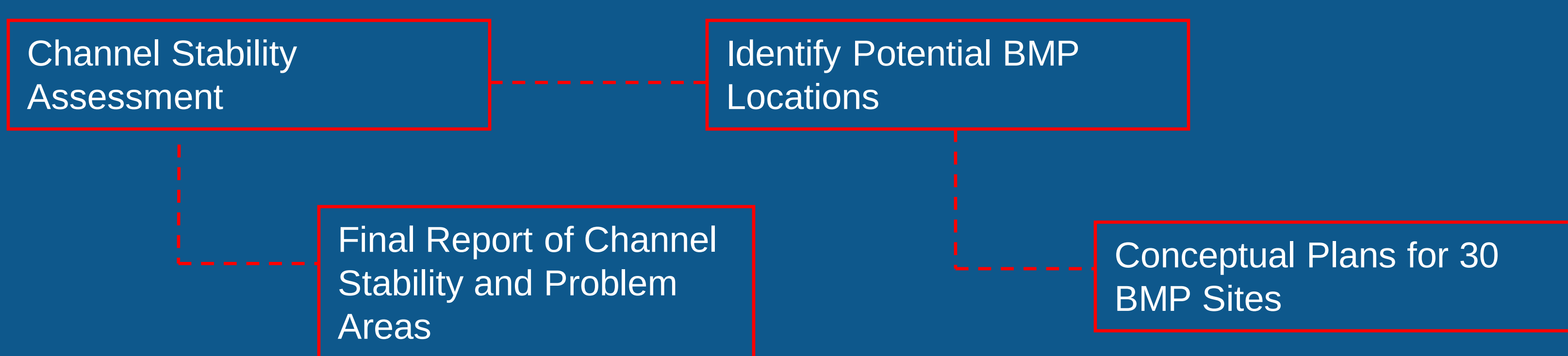
  - **Slate Belt-**cobble and large gravel streams, steep topography and narrow alluvial valleys.
  - **Triassic Basin-**sand bed streams.

EARTH TECH | AECOM



Background of Project

- Bolin Creek on the Federal 303(d) list of impaired streams due to biological impairment.
- The Towns of Carrboro and Chapel Hill formed the Bolin Creek Watershed Restoration Team (BCWRT) with the goal of removing Bolin Creek from the Federal 303(d) list.
- Objectives of the Bolin Creek Project:
  - Analyze the geomorphic state of the streams within the watershed to assess areas and causes of impairment.
  - Propose areas where stormwater best management practices (BMPS) or retrofits could be implemented to improve water quality.
- Goal of 30 BMP Sites.



Background of Project

- Watershed studies had already been conducted on Bolin Creek:
- A local watershed plan prepared for the NC Wetlands Restoration Program (now NC Ecosystem Enhancement Program).
- A watershed restoration plan.

Earth Tech's Approach

- A GIS desktop analysis of the watershed, followed by a field survey of specified areas will not reveal as many possible sources of water quality degradation as are needed.
  - Reasoning: Spatial scale of GIS data is often too large and limited to pinpoint specific areas of stream degradation and pollutant input.

- **Instead:**
- Need a foot survey of every intermittent and perennial stream within the watershed.
- Record both quantitative and qualitative data on geomorphic condition of stream channels, sources of instability, and locations of potential BMP solutions to these problems.
- GIS used to provide initial base maps and post-survey analysis of pollutant removal potential, pollutant input, etc.

Earth Tech's Approach

Challenges:

- 80 miles of stream to walk
- Only a few months to complete
- Coordination of a field crew consisting of staff from public agencies, municipalities, and private consulting.
- Relatively small budget compared to past projects.

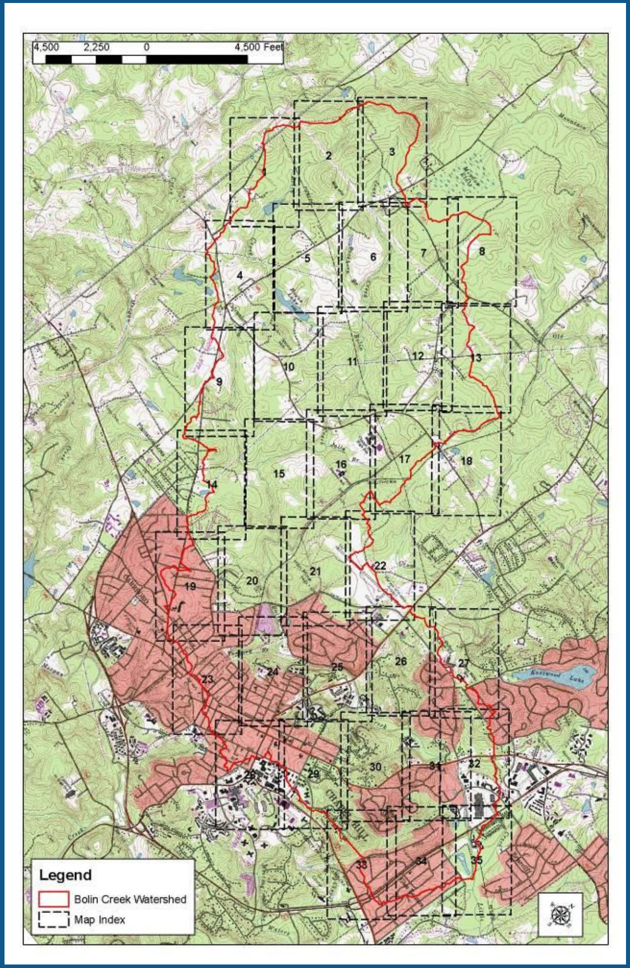
Final Product:

- Atlas of at least 30 BMP projects with conceptual plans and cost estimates.

Methods

Field effort:

- The watershed was divided into a grid, with each cell represented on a field map. Field maps sequentially numbered from the upper watershed to the lower watershed.
- Field maps based on topographic and aerial photography and contained relevant GIS data including streams (intermittent, perennial, and ephemeral), roads, known stormwater outfall locations, sewer lines, and impervious surfaces.
- Two to three person teams.
- Teams consisted of a mixture of staff from agencies and consulting, as a way to learn from each other.



Earth Tech's Approach

- As each team walked along the riparian areas of streams, a datapoint was collected at observed changes in the general stability of the stream, at locations of specific stormwater inputs to the stream (stormwater outfalls, dams, ditches), or anywhere else general changes in stream stability were noted.
- Ephemeral streams were walked in addition to all intermittent and perennial streams, as many sources of instability were observed in ephemeral drains and swales.
- Data was also collected where a BMP retrofit, new BMP construction, or other water quality solution could be implemented.

- Data was recorded in three locations:
  1. A standardized field form:
     - Field form contained a mixture of quantitative and qualitative information to be recorded.
     - The form provided a consistent means of comparing the relative severity of each location, and was critical for later comparison and prioritizing of instability areas.

EARTH TECH | AECOM

Methods

STREAM NAME: UT	**DATE: 6/6/07**	**MAP SHEET #: 21**
PHOTO NUMBERS: 1113-1116	**LANDMARK: RR AND SEAWELL RD**	**SKETCH ON BACK**

GPS ID START: TA 26 **DESCRIPTION:**	**GPS ID END: TA 26** **DESCRIPTION:**
RAIN IN LAST 24 HOURS ☐ Heavy rain X Steady rain ☐ None ☐ Intermittent ☐ Trace	**PRESENT CONDITIONS** ☐ Heavy rain ☐ Steady rain ☐ Intermittent X Clear ☐ Trace ☐ Overcast ☐ Partly cloudy

SURROUNDING LAND USE: ☐ Industrial ☐ Commercial ☐ Urban/Residential ☐ Suburban/Res ☐ Forested ☐ Institutional ☐ Golf course ☐ Park ☐ Crop ☐ Pasture X Other: RAILROAD

BASE FLOW WIDTH AS % CHANNEL WIDTH ☐ 0-25% ☐ 25-50 % ☐ 50%-75% NA-Upland erosion ☐ 75-100%	**WATER CLARITY** ☐ Clear ☐Turbid *(suspended matter)* ☐ Stained *(clear, naturally colored)* ☐ Opaque *(milky)* ☐ Other (chemicals, dyes) NA

DOMINANT SUBSTRATE 1 Silt/clay (fine or slick) 2 Sand (gritty) ☐ Gravel (0.1-2.5") ☐ Cobble (2.5 –10") ☐ Boulder (>10") ☐ Bed rock	**CHANNEL DIMENSIONS AT RIFFLE** **Height**: Low bank ________(ft) **Width**: Bottom ________(ft) Top ________(ft) Water Surface ________(ft) **Depth:** Max BKF ________(ft) **B:H Ratio:** Low bank/Max BKF=________	**OBSERVED IMPACTS** ☐ Outfall ☐ Confluence ☐ Impacted buffer ☐ Stream crossing ☐ Channel mod ☐ Utility impacts ☐ Beaver ☒ Other - railroad

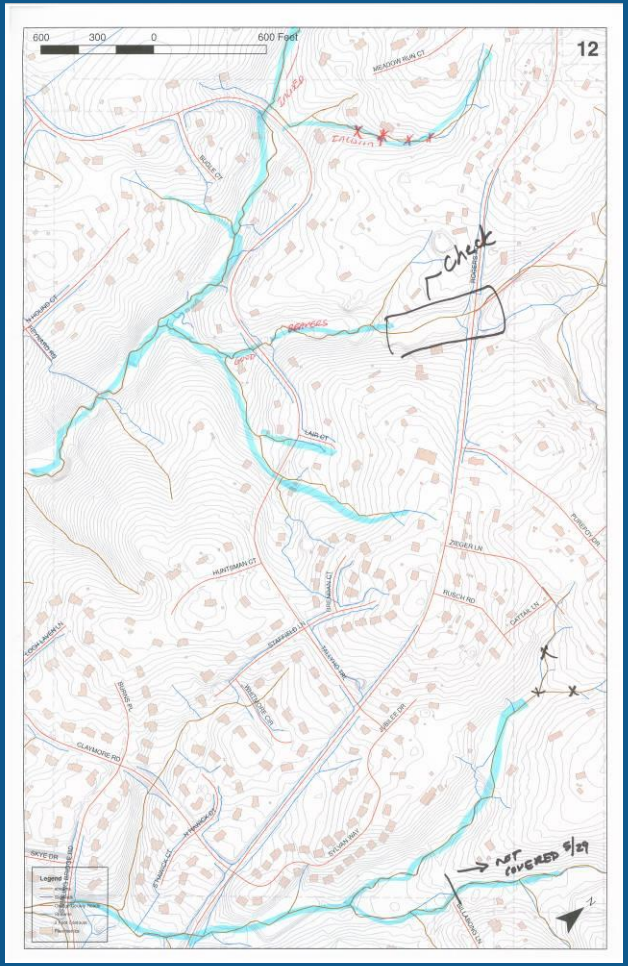
CHANNEL DYNAMICS ☐ Downcutting ☐ Bed scour ☐ Slope failure ☐ Widening ☐ Bank failure ☐ Channelized ☐ Headcutting ☐ Bank scour ☐ Unknown ☐ Aggrading ☐ Sed. deposition	**NOTES** **RAILROAD ALL THROUGH THE WS SEEMS TO BE A SIGNIFICANT CONTRIBUTOR**
QUALITATIVE IMPAIRMENT RATING: ☐ Low ☐ Moderate X Severe	**CHANNEL EVOLUTIUON STAGE:** ☐ I ☐ II ☐ III ☐ IV ☐ V ☐ VI *(Simon et. al., 2003)*

EARTH TECH | AECOM

Methods

- 2. Field maps- provided a means for the field crew to sketch the relationship and perceived connection of instability areas in relation to the landscape and topography.

- 3. Individual notes in a log book- provided a location for field crew to write a brief narrative of what they observed, or of any features that may not be noted on the field form.



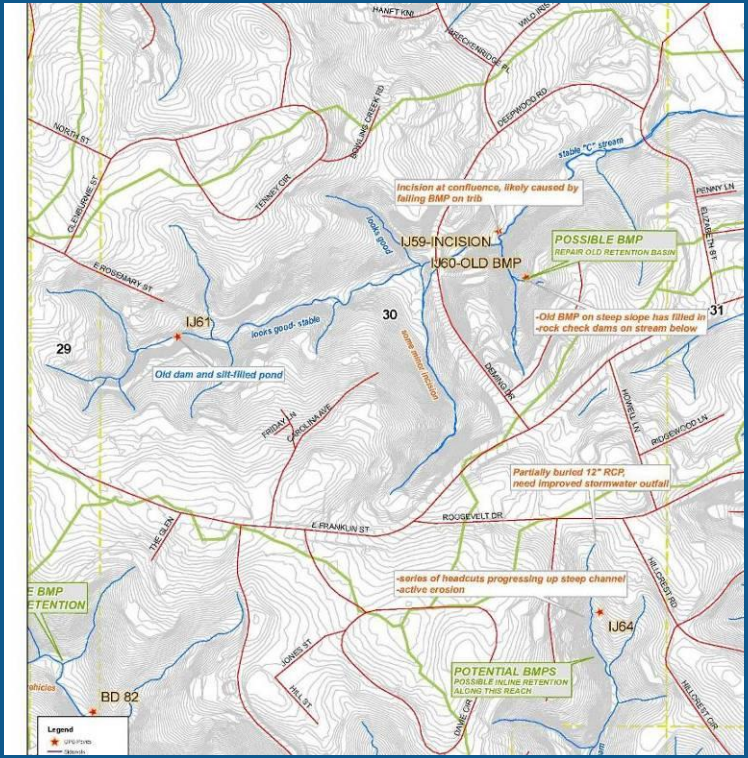
Methods

- Also collected:
  - GPS points.
  - Photos of each datapoint location.

- “Raw data” summary:
  - Data from three record-sources was combined and digitized onto field maps for review by the BCWRT.
  - Concept of the digitized map was to provide a summary of the “raw data” collected during the field effort.
    - Provided an easy means of review by stakeholders for decisions of prioritization of BMP sites.
    - Provided a master reference of the field survey to guide future efforts in the watershed by the BCWRT.

Methods

- “Raw Data Maps” also linked with a point code to the field forms for each datapoint/site.
- These two items presented to the BCWRT at stakeholders meeting.
- Results of meeting: selected 30 sites for further study of feasibility and implementation of BMPs.



Methods

- 2nd Field Effort:

- Revisited priority sites to develop conceptual plans and cost estimates for BMPs.
- Effort involved greater degree of engineering and hydrologic analysis.
- For each site, data was collected on:
  - Type of BMP needed
  - Area that was available
  - Locations of necessary elements of BMP
  - Potential impacts to surrounding area
  - Ease of access
  - Visibility of the site

Methods

For bank erosion sites:

- Primary concern was export of sediment from eroding streambanks.
- Observed as a major problem throughout the watershed, and a probable contributor to the biological impairment of Bolin Creek.

- At these sites, the BANCS model, as described in the WARSSS method (Watershed Assessment of River Stability and Sediment Supply) was used to estimate total tons of sediment exported from these sites due to bank erosion.

Methods

Post-field work:

- Developed conceptual BMP designs
  - Cost-benefit ratios used to prioritize sites
  - Cost-estimates
  - A written narrative for each site
  - Plan views
- Project atlas contained a total of 32 projects.

Results

− Examples of construction cost, pollutant removal potential and ranking system used:

Table 2. BMP Ranking Criteria and Point Allocation

	BMP Ranking Criteria (20 Total Points Possible)	Possible Points
1	**Cost/Ton of Sediment Reduced**	**5**
	Less than $50	[5]
	Between $50 and $200	[4]
	Between $200 and $300	[3]
	Between $300 and $500	[2]
	Greater than $500	[1]
2	**Cost/ lb of Nutrients Removed**	**5**
	Less than $9,500	[5]
	Between $9,500 and $23,000	[4]
	Between $23,000 and $50,000	[3]
	Between $50,000 and $80,000	[2]
	Greater than $80,000	[1]
3	**Project Visibility**	**5**
	Poor (site cannot be seen from street)	[1]
	Good (site adjacent to a street)	[3]
	Excellent (site adjacent to a highly traveled street or public property)	[5]
4	**Construction Access**	**5**
	Poor	[1]
	Good	[3]
	Excellent	[5]
5	**Critical Nature of Project**	**5**
	Critical (exponential increase of problem is expected if project is delayed; i.e. headcut causes channel incision which causes decades of channel instability and is order of magnitudes higher if you wait to repair)	[5]
	Very High (problem will increase in future at a steady rate)	[4]
	High (problem will increase, but range of future impact is limited)	[3]
	Medium (problem is severe but not expected to increase significantly)	[2]
	Low (problem is present, but stable, no expected increase)	[1]

Table 9.1

Pre-Treatment	
Estimated Total Sediment Export	95.1 tons/year
Erosion per length of Channe	1.4 tons/yr/ft
Pounds of Nitrogen	190.2 lbs/year
Pounds of Phosphorus	95.1 lbs/year
Post-Treatment	
Estimated Total Sediment Export	0.2 tons/year
Erosion per length of Channe	0 tons/yr/ft
Pounds of Nitrogen	0.4 lbs/year
Pounds of Phosphorus	0.2 lbs/year

Table 9.2
Site 9 Construction Cost

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Excavation	62.0	CY	15.00	$930
Stormwater Wetland	2534.0	CF	Equation Derived	$7,159
Site Preparation and Planting	0.1	AC	7500.00	$750
Rip Rap Class B	10.0	Tons	45.00	$450
Filter Fabric	30.0	SY	5.00	$150
Silt Fence	200.0	LF	3.75	$750
Construction Safety Fence	260.0	LF	2.50	$650
Construction Entrance	2.0	Ea	2500.00	$5,000
			Total	$15,839
Mobilization (5%)	1.0	LS		$792
Contingencies (10%)	1.0	LS		$1,584
	Total + Mobilization and Contingencies			**$18,215**
Maintenance Costs				
Maintenance (5% of base construction cost)	1.0	Year		**$911**

Results

– Summary of final projects:

Table 3. Summary of Final BMP Sites and Scoring

Final Site Name	Type of Project	Cost of Construction	Location	Cost/ton of sediment		Cost/ lb nutrients Removed		Project Visibility		Construction Access		Critical Nature of Project*		Total Score Nutrient Projects	Total Score Sediment Projects
					(pts)		(pts)		(pts)		(pts)		(pts)		
1	Dam Retrofit	$30,964	Outside	$21.46	5			Poor	1	Excellent	5	High	3		**14**
2	BMP- Retrofit	$43,879	Carrboro			$8,200.78	5	Excellent	5	Excellent	5	Low	1	**16**	
3	Stream Bank Stabilization	$31,734	Outside	$197.53	4			Poor	1	Good	3	Critical	5		**13**
4	BMP- Retrofit	$73,509	Carrboro			$98,769.50	1	Poor	1	Poor	1	Medium	2	**5**	
5	BMP- Retrofit	$22,660	Carrboro			$10,031.09	4	Good	3	Excellent	5	High	3	**15**	
6	BMP- Retrofit	$34,578	Carrboro			$15,307.01	4	Good	3	Excellent	5	High	3	**15**	
7	BMP- Retrofit	$100,619	Carrboro			$44,542.49	3	Good	3	Excellent	5	Very High	4	**15**	
8	BMP- Retrofit	$19,017	Carrboro			$3,504.29	5	Good	3	Excellent	5	Medium	2	**15**	
9	Stream Bank Stabilization	$18,215	Carrboro	$191.92	4			Good	3	Good	3	Medium	2		**12**
10	BMP-New Construction	$48,336	Carrboro			$9,121.72	5	Poor	1	Good	3	Medium	2	**11**	
11	BMP- New Construction	$30,323	Chapel Hill			$28,285.41	3	Excellent	5	Excellent	5	Medium	2	**15**	
12	BMP- New Construction	$69,358	Chapel Hill			$22,467.50	4	Poor	1	Good	3	Medium	2	**10**	
13	BMP- New Construction	$25,688	Chapel Hill			$2,353.10	5	Poor	1	Poor	1	Medium	2	**9**	
14	BMP- New Construction	$25,688	Chapel Hill			$6,416.48	5	Good	3	Excellent	5	Medium	2	**15**	
15	BMP- Retrofit	$27,266	Chapel Hill			$23,281.67	4	Poor	1	Good	3	Very High	4	**12**	
16	Stream Bank Stabilization	$56,479	Carrboro	$282.81	3			Excellent	5	Poor	1	Medium	2		**11**
17	Stream Bank Stabilization	$66,649	Carrboro	$1,098.79	1			Poor	1	Poor	1	Very High	3		**6**
18	BMP- New Construction	$17,416	Chapel Hill			$14,828.54	4	Good	3	Good	3	Very High	4	**14**	
19	Stream Bank Stabilization	$8,884	Carrboro	$319.81	2			Excellent	5	Excellent	5	Medium	2		**14**
20	Stream Bank Stabilization	$49,479	Chapel Hill	$26.04	5			Excellent	5	Good	3	Very High	4		**17**
21	Stream Bank Stabilization	$52,104	Chapel Hill	$74.33	4			Good	3	Poor	1	Critical	5		**13**
22	Stream Bank Stabilization	$72,526	Chapel Hill	$38.42	5			Excellent	5	Excellent	5	Very High	4		**19**
23	BMP- Retrofit	$32,030	Chapel Hill			$65,099.01	2	Poor	1	Poor	1	Low	1	**5**	
24	BMP- New Construction	$107,541	Chapel Hill	$285.11	3	$49,502.23	3	Good	3	Poor	1	Critical	5	**12**	
25	BMP- New Construction	$84,571	Chapel Hill			$52,133.47	2	Poor	1	Poor	1	Low	1	**5**	
26	BMP- New Construction	$69,375	Chapel Hill			$83,059.38	1	Poor	1	Poor	1	Low	1	**4**	
27	BMP- New Construction	$38,554	Chapel Hill			$213,283.40	1	Poor	1	Poor	1	Low	1	**4**	
28	BMP- New Construction	$36,660	Chapel Hill			$22,209.33	4	Poor	1	Poor	1	Low	1	**7**	
29	BMP- New Construction	$81,218	Chapel Hill	$144.51	4	$40,728.87	3	Poor	1	Poor	1	Very High	4	**9**	
30	BMP- Retrofit	$28,501	Chapel Hill			$3,625.74	5	Poor	1	Poor	1	High	3	**10**	
31	BMP- New Construction	$20,130	Chapel Hill	$38.91	5	$15,809.47	4	Poor	1	Good	3	High	3	**11**	
32	Stream Restoration	$207,000	Chapel Hill	$3,522.80	1			Excellent	3	Poor	1	Low	1		**6**

Example Projects

Site 3

- Stabilization of headcut on Intermittent Channel.
- Above headcut:
  - Intermittent stream is relatively stable, low bank height ratio

Example Projects

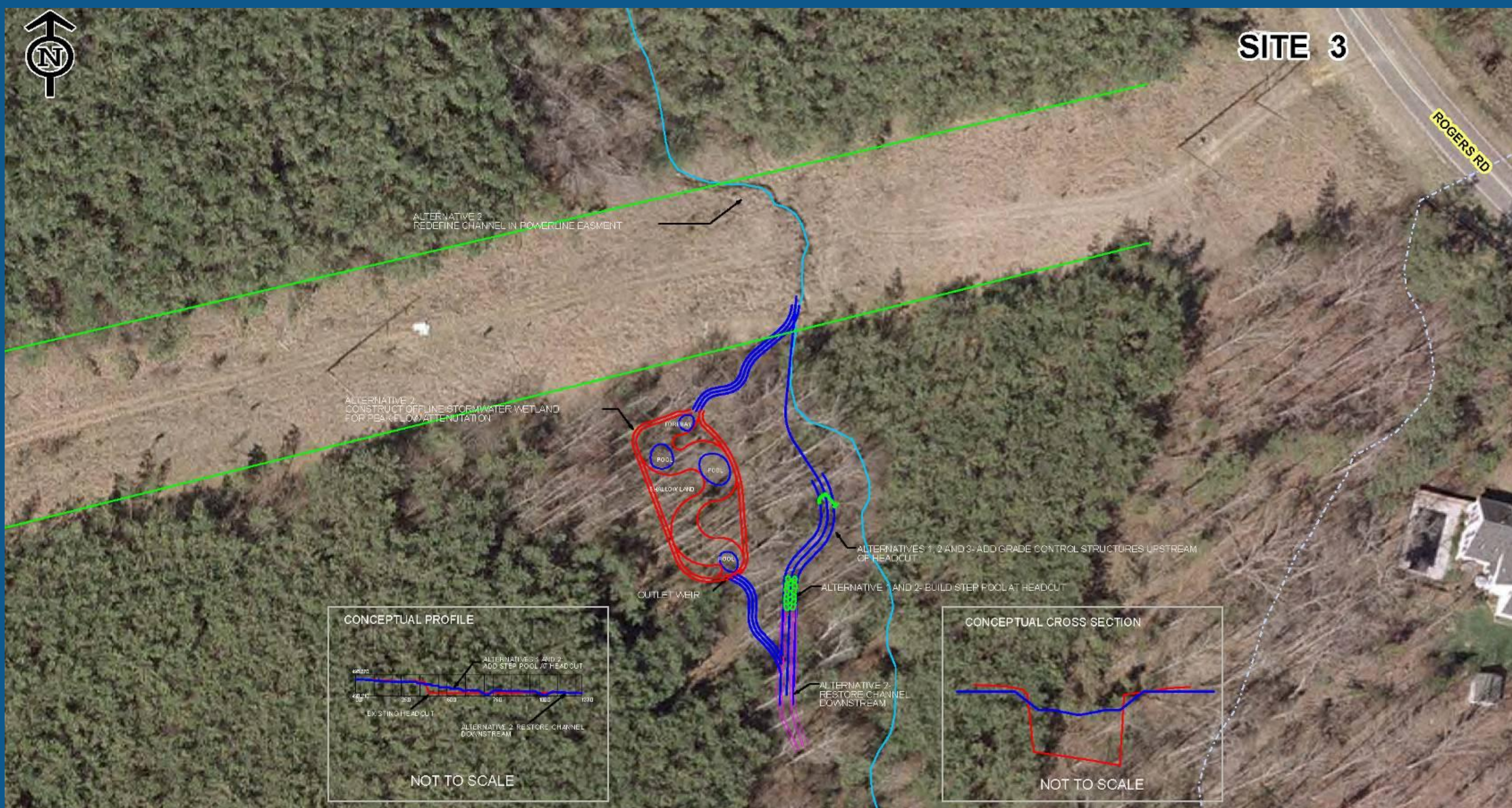
Site 3

− Below headcut:

Example Projects

Site 3

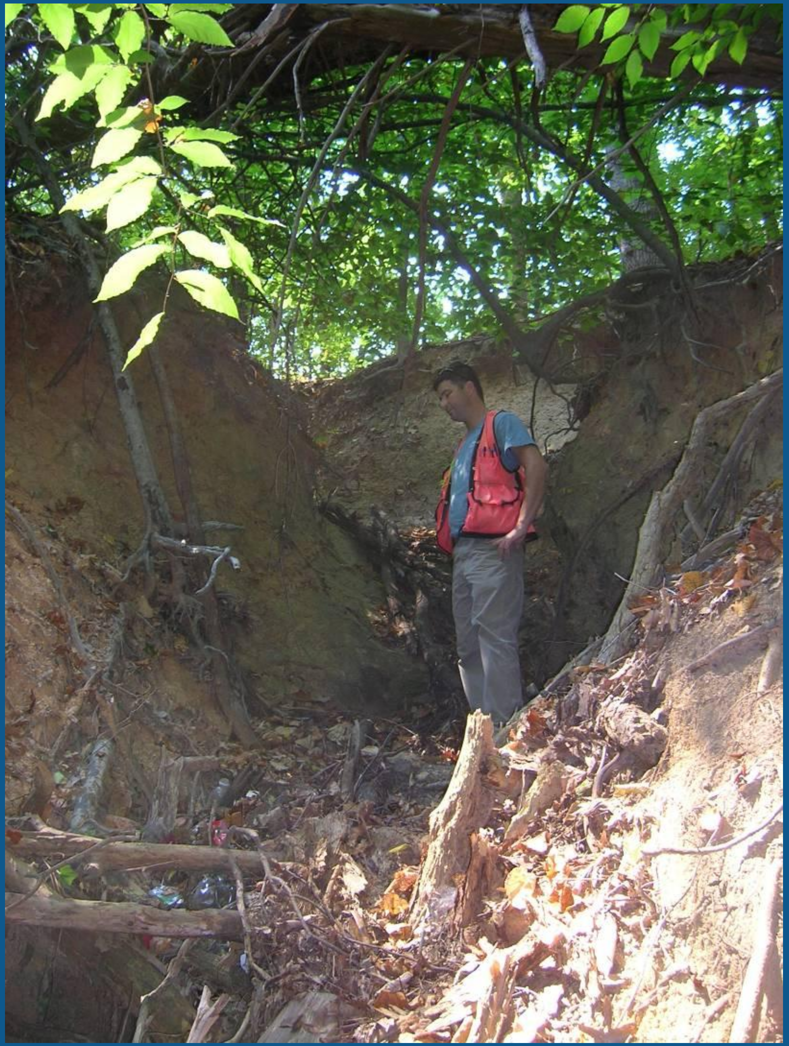
− Conceptual solution:



Example Projects

Site 21

- Restoration of stormwater outfall and gulley
- Gulley created by stormwater being discharged from outfall directly above a steep hillside.
- Example of the many sources of instability in the watershed caused by stormwater infrastructure.



Example Projects

Site 21

- Proposed solution:
  - 2 alternatives:
    1. "Hard" engineering solution
       - Construction concrete flume with friction blocks.
    2. or natural channel design
       - Convert gulley into "A"-type channel, placing large boulders into the gulley.

In both alternatives: construct dissipation basin at bottom of hill, then allow diffuse flow through vegetated buffer into stream.

Example Projects

Site 21

Example Projects

Site 18

- Restoration of erosive gulley beneath railroad trestle and water quality treatment of runoff from subdivision.

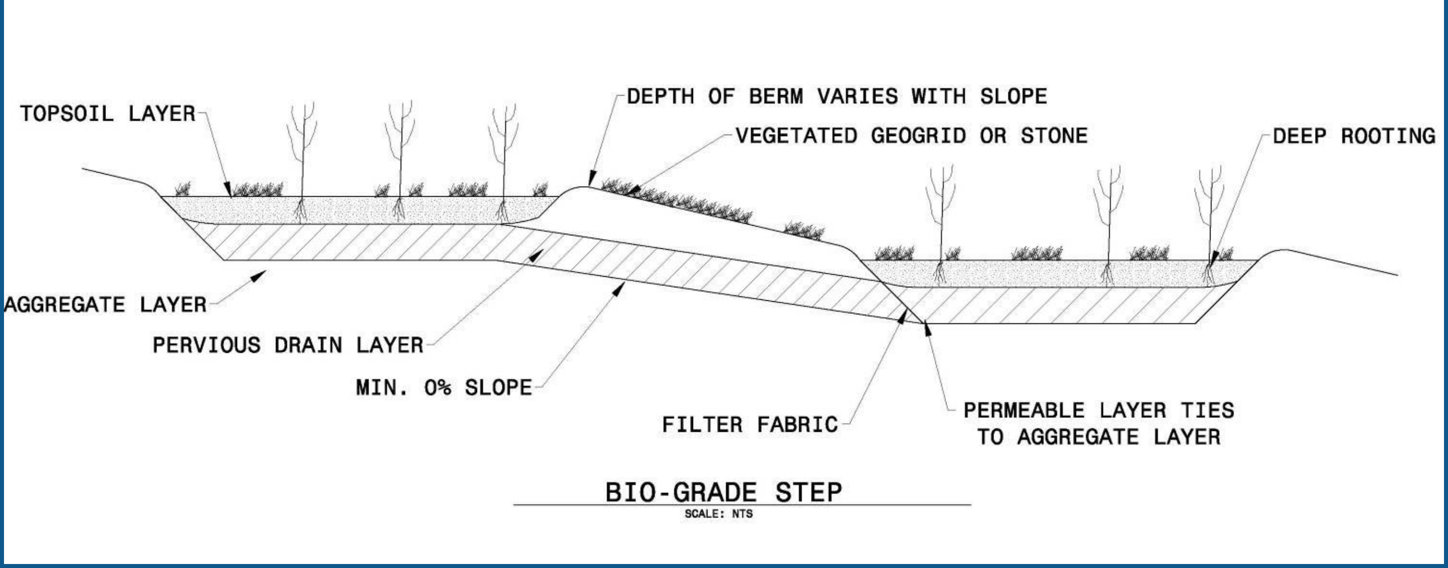
- Hillside erosion occurring because no stormwater control from railroad.
- Small channel also receives stormwater flow from roads and rooftops of large subdivision uphill.

Example Projects

Site 18

Solution:

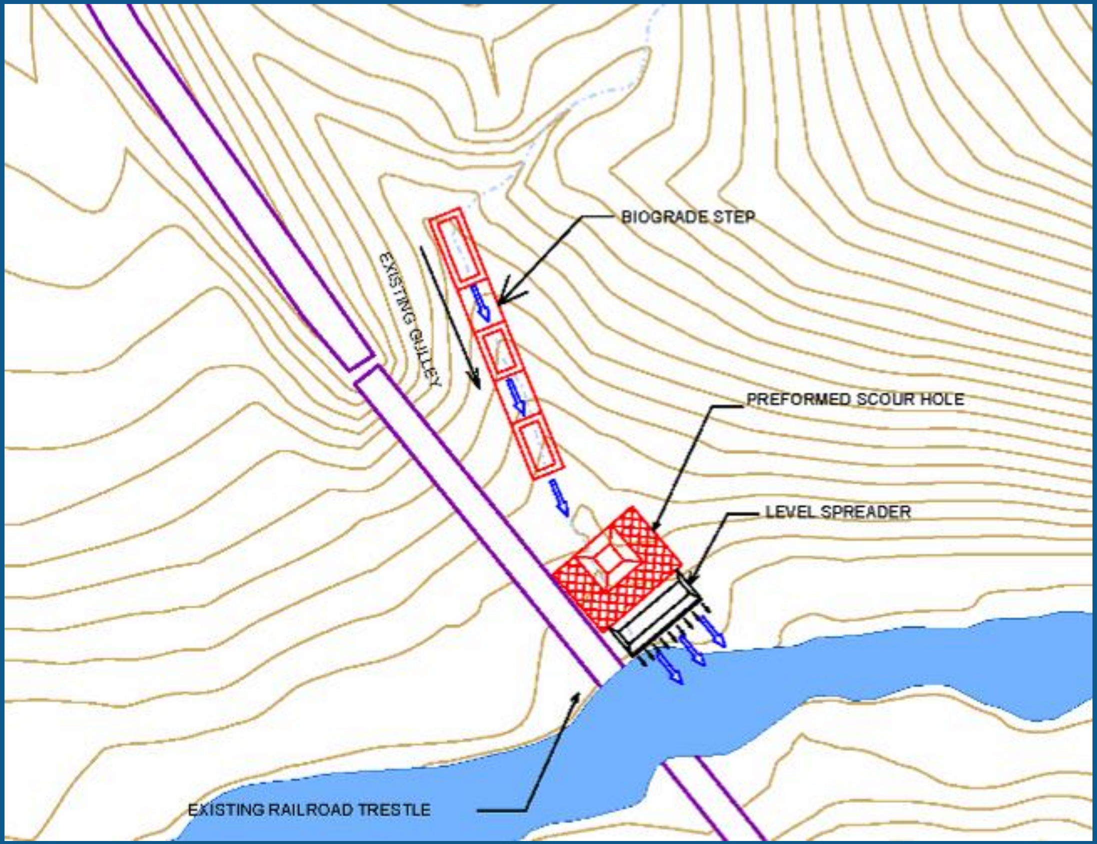
- This was an example of steep hillside erosion where both stabilization for reduction of sediment export and construction of a stormwater BMP for water quality treatment of impervious runoff could be implemented.
- Steepness and narrowness of site pose limitations to traditional BMP solutions.
- “Bio-grade step” was seen as an effective solution.



Example Projects

Site 18

Illustration of topography of site and proposed solution:



Example Projects

Site 18

Aerial view:

Reflections on the Project

Observations from walking the watershed:

- Changes in stream stability are very dynamic along even single stream reaches within a watershed.
- While a stream can be deeply incised, or contain a headcut, a single “knick point” such as a bedrock outcrop can serve as grade control, downstream of which the stream exhibits much less instability.
- Typical predictors of stream degradation used in GIS analysis, such as presence or absence of riparian buffer and percent impervious surface, are not by themselves determinative of the condition of a stream.

Reflections on the Project

Important results of the project:

- The project has helped to provide a metric for the cost of a ground-based, stream geomorphology study focused on producing specific solutions to improve water quality within a watershed.

- Cost of the assessment:
  - $450-$500/mile of stream assessed.
  - $2000 /BMP site assessment.

- Provides a reasonable guidepost for the cost of similar watershed assessments in the Southeast.

Reflections on the Project

Advantages of the method used in this assessment:

- Field survey is comprehensive.
- Provides “snapshot” of geomorphic state of watershed, including supplemental information such as broken outfalls, buried pipes, illegal dumping activities.
- Allows for identification of specific retrofit possibilities for water quality treatment.

Disadvantages:

- Data collected limited to a mixture of qualitative and quantitative, rather than purely quantitative, due to time constraints.
- Field staff must be familiar with stream geomorphology (recognize bankfull, incision ratio, etc.) and BMP possibilities (types of BMPs and associated state regulations for where they can be placed).

How the conditions of the project could differ from others in the conducted in the Southeast:

- Landowners in the Carrboro-Chapel Hill area were overwhelmingly willing to allow access to their properties when sent notice letters.
- The urban-suburban nature of the watershed means less physical barriers (fences, gates) to conducting an on-foot study.

Conclusions

Why a study of this nature is important:

- Increasingly stringent water quality laws, such as NPDES Phase II, are pushing local governments to “put the shovel to ground” when it comes to water quality.
- Urban watersheds such as Bolin Creek need a quick, cost-effective solution to identify problems and implement solutions, rather than getting bogged down in “analysis paralysis”.
- It is important for those conducting these studies to give feedback on costs to the greater watershed community, so that the practice can improve as a whole and so that local governments can make informed decisions about how best to address the water quality problems facing their communities.